Change of breast height diameter with age of *Swietenia macrophylla* (mahogany) even-aged monocultures

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1.0 Introduction

Swietenia macrophylla (mahogany) is native to North America and now it covers a wide range of terrestrial areas in the world including tropical countries. The suitability of mahogany as a plantation crop has led to established 200, 000 ha of plantations worldwide, with extensive areas in Fiji and Philippines (Platino, 1997). In Sri Lanka private sector also started to establish mahogany monocultures specially in the intermediate zone and low country wet zone. However mahogany plantations in the country have not been able to most productive to attract further financial out comes. Nevertheless, information on growth of mahogany is not readily available in Sri Lanka. Since as a solution for this, need to establish appropriate management guidelines for mahogany monoculture plantations. Prior to introduce such management strategies, necessities are identifying growth rates and growth differences of plantation crop of mahogany. Hence this study concerning with distribution of breast height diameter (dbh) of mahogany trees growing in different site types with their age is vital requirement for the plantation sector.

2.0 Materials and methods

Study was considered relationship between breast height diameter and age in pure mahogany monocultures in different site types in wet zone of Sri Lanka in order to establish empirical model to represent correlation between two parameters.

2.1 Study sites

Data were collected from sixteen mahogany monocultures in Kalutara, Ratnapura and Matale districts and age of these plantations range from one year to eight years old. Within the mentioned age range at least two plantations were selected for data collection whenever possible. In order to represent whole plantation reasonably, each of them was categorized into good, moderate and poor sites based on the growth differences. Figure 3.1 illustrates locations of the plantations.

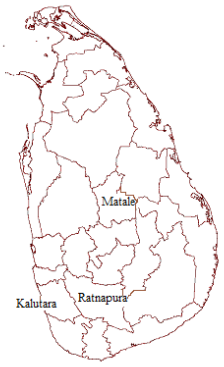

Figure 3.1: Locations of the plantations

Twenty trees were randomly selected from each site of one plantation and altogether sixty trees were chosen from each plantation. Diameter at breast height and age of each plantation were considered as two variables to construct growth model for young mahogany monocultures in Sri Lanka.

2.2 Model construction

MINITAB and GENSTAT statistical software were used for model construction. In a preliminary stage of the analysis, relationship between dbh and age of mahogany monocultures in respect to good, moderate and poor site types was identified graphically. Possible out liars were eliminated at the beginning of the analysis. In order to recognize the magnitude of the two variables and the direction of the relationship between dbh and age of mahogany, correlation coefficient (r) was used

prior to formulate the model. Theoretical basic model structure was developed to express relationship between dbh and age for each site types. Regression analysis was applied for the purpose of parameter estimation in the basic model structure for three different site types. Basic structure was tested with linear regression and non-linear regression analysis using MINITAB and GENSTAT statistical software respectively. Intention on preparing biologically sound and high performing models for this relationship both untransformed and transformed explanatory variables such as square, square root, logarithmic and inverse were tested for the model.

2.3 Selection of the best models for each site types

The best models for dbh and age relationship for good, moderate and poor sites were selected statistically by using coefficient of determination (R^2) and residual plot analysis. Residuals were graphically analyzed and investigated adequacy of the models and the robustness of the models to the data set. However, to remain similarity among models for good, moderate and poor sites for dbh and age of mahogany, always consider same structure for all these site types.

2.4 Construction of common model

Intention on reduced the complexness of using three different parameters for same basic structure for dbh and age of mahogany for good, moderate and poor sites, application of common model for all site types was tested statistically using pooled data of all site types. Validation of the common model for all site types was tested with one way ANOVA and Turkey's pair wise comparison test at the 95% probability level with normal residuals for good, moderate and poor sites. If the results were not significant, common model will be appropriate for all three site types and if the result was significant, site specific models should be used and common model will be not adequate for better prediction.

2.5 Improve the model that were significant

Due to previously mentioned strategy was failed to produce reliable common model, analysis steps were further forward to find any possibility to build common model for dbh and age of mahogany. Multiple linear regression analysis was tested with additional explanatory variable called site index (average height/age) for pooled data as another effort for constructing common model. As previously, transformed and untransformed variables were tested with multiple linear regression analysis each time. Normal residuals for separate site classes with newly constructed parameter were tested with one way ANOVA at the 95% probability. Improved model was used as a common model for mahogany all site types.

3.0 Results

Site specific growth models with three different parameters for dbh and age relationship for good, moderate and poor sites of mahogany monocultures are final outcome from this study. Figure 3.1 illustrates dbh distribution for all measured plantations.

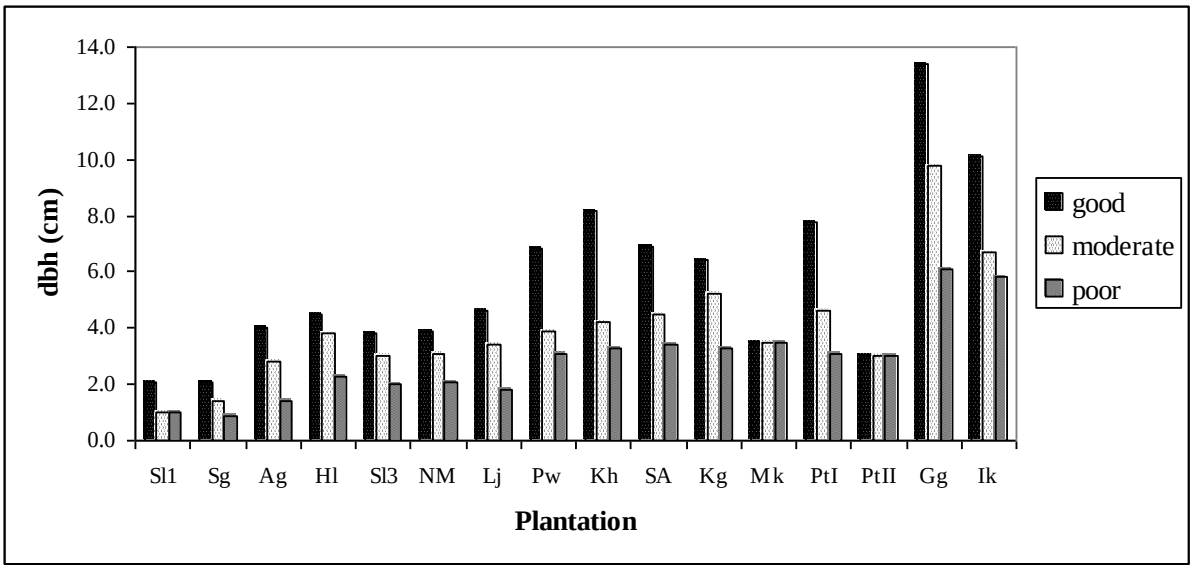

Figure 3.1: dbh distribution of plantations used for this study (Sorted in ascending order on age)

Gomaragala (Gg) plantation which is seven years old has the highest dbh for different growth types. Dbh values however, in Ihalakanda (Ik) plantation which is eight years old lower than that of Gomararagala. Mean values for dbh in Kalugalhena (Kh), St Anthony's (SA), Panthiya I (Pt_I), Kukuleganga (Kg) and Pelawatta (Pw) plantations range between 6.0 cm to 8.0 cm. Dbh values in other plantations range between 1.0 cm to 4.0 cm.

3.1 Selected best models

Finally selected three site specific models for three site types (good, moderate and poor) dbh has an exponential relationship with height. Equations of 3.1, 3.2, and 3.3 respectively represent growth models for good, moderate and poor sites.

$$dbh = 2.443*1.207^{age} \quad (3.1)$$

$$dbh = 1.736*1.184^{age} \quad (3.2)$$

$$dbh = 0.919*1.267^{age} \quad (3.3)$$

Figure 3.2 illustrates the fitted lines of the models built to predict dbh vs age. The R^2 values for good, moderate and poor sites are 78.8%, 71.2%, and 81.5% respectively.

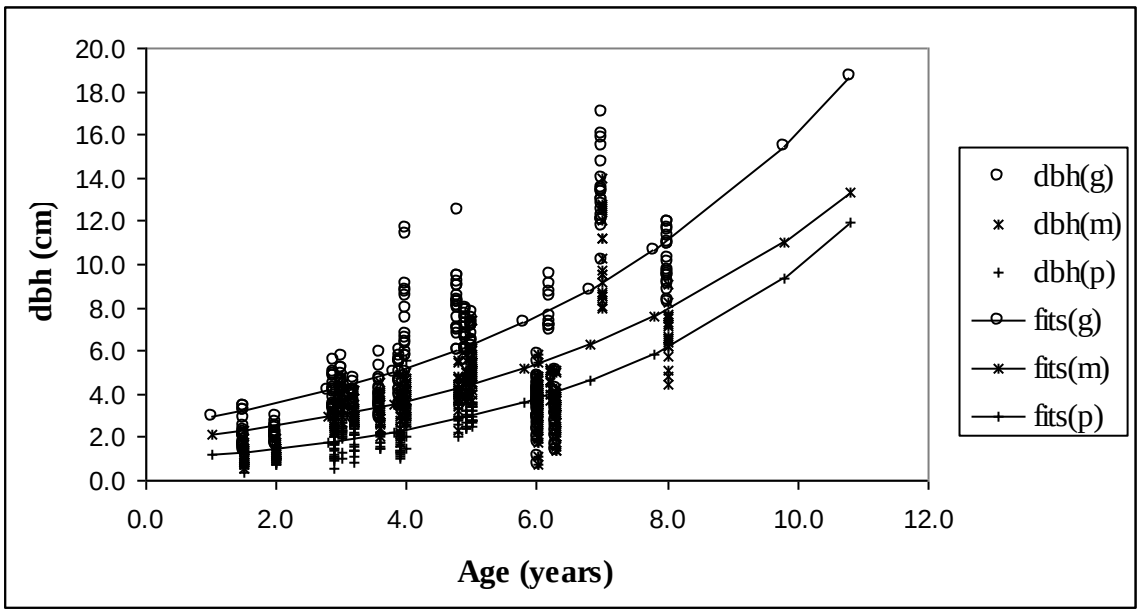

Figure 3.2: Fitted line plot of dbh vs age for three site classes.

The R^2 values were above 70% and the residual distributions were good. Finally, a height based site/growth classification system was also introduced in this study, so that the appropriate model can be used referring the growth quality table (table 3.1).

Age (year)	Poor growth	Moderate growth	Good growth
2	< 2.0 m	2.1 - 3.4 m	> 3.5 m
3	< 2.5 m	2.6 - 3.9 m	> 4.0 m
4	< 4.0 m	4.1 - 5.9 m	> 6.0 m

5	< 4.5 m	4.6 - 6.4 m	> 6.5 m
7	< 5.0 m	5.1 - 7.9 m	> 8.0 m
8	< 5.5 m	5.6 - 8.4 m	> 8.5 m

Table 3.1: Growth quality table

4.0 Conclusion and recommendation

Site quality highly affected for the growth of mahogany and most of the times dbh of the mahogany trees were highly correlated with age of the trees. Prediction power of non-linear models is higher than linear models. Constructed models can be used to predict dbh with age. Age range of mahogany monocultures are restricted in to younger plantations due to lack of mature monocultures in Sri Lanka. So that the study can be extended with more data collected from mature plantations.

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